
Liquid Argon TPC electronics for T962

Dan Edmunds



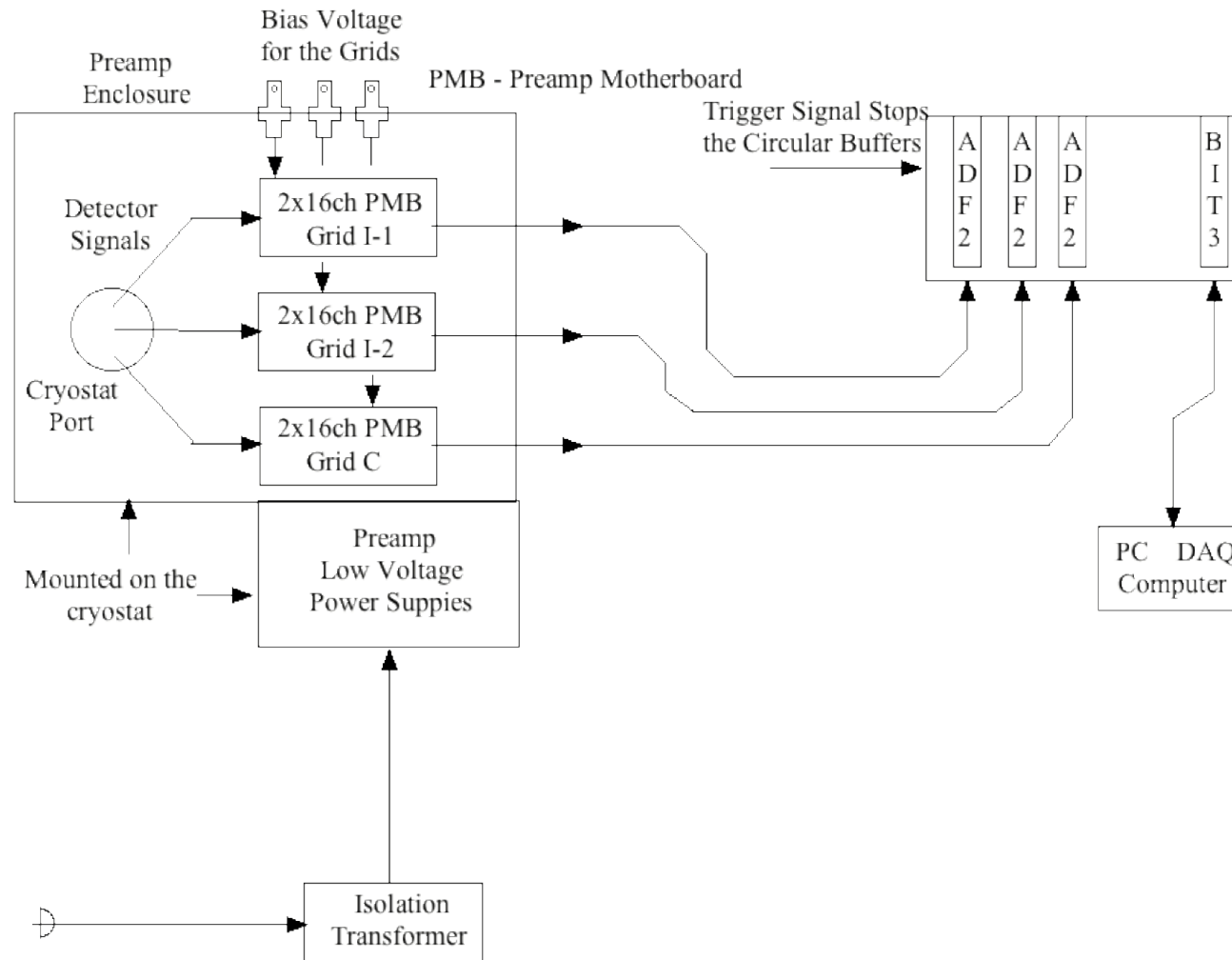
Carl Bromberg
Michigan State University

Largely the work of
Dan Edmunds - engineer/hardware design
Phillipe Laurens - engineer/DAQ software

PAB Program and Status

- Goal has been to develop DAQ electronics for a Large LArTPC
 - Careful study of ICARUS (2 x 300 Ton) electronics
 - Conclude that a multiple FET front end is unbeatable (if warm)
 - ICARUS 10 year-old electronics design is obsolete and unavailable
 - Commercial electronics suppliers are problematic - better to be in-house
 - Develop an independent capability using modern components
 - Testing Run II D0 hybrid preamplifiers (not in use, many available)
 - MSU designed ADC-FPGA for Run II D0 trigger (2nd level spares)
 - Single channel tests with simulated signals - intrinsic noise under control
 - Make prototype preamp motherboards for a 96 channel TPC
 - Mount a few channels (or boards) on the cryostat for noise evaluation
 - See cosmic muon tracks in Argon before Spring 2007.
 - Missed this target - causes: preamplifier housing design & safety reviews
 - Electronics and DAQ are installed and readout has been tested.
 - System noise is under control - ready for liquid.
 - Afterward investigate COLD electronics: preamps, etc.

Preamplifier and DAQ schematic



Hybrid preamplifier

D-zero Run-II

LAr preamp

Dual FET input stage

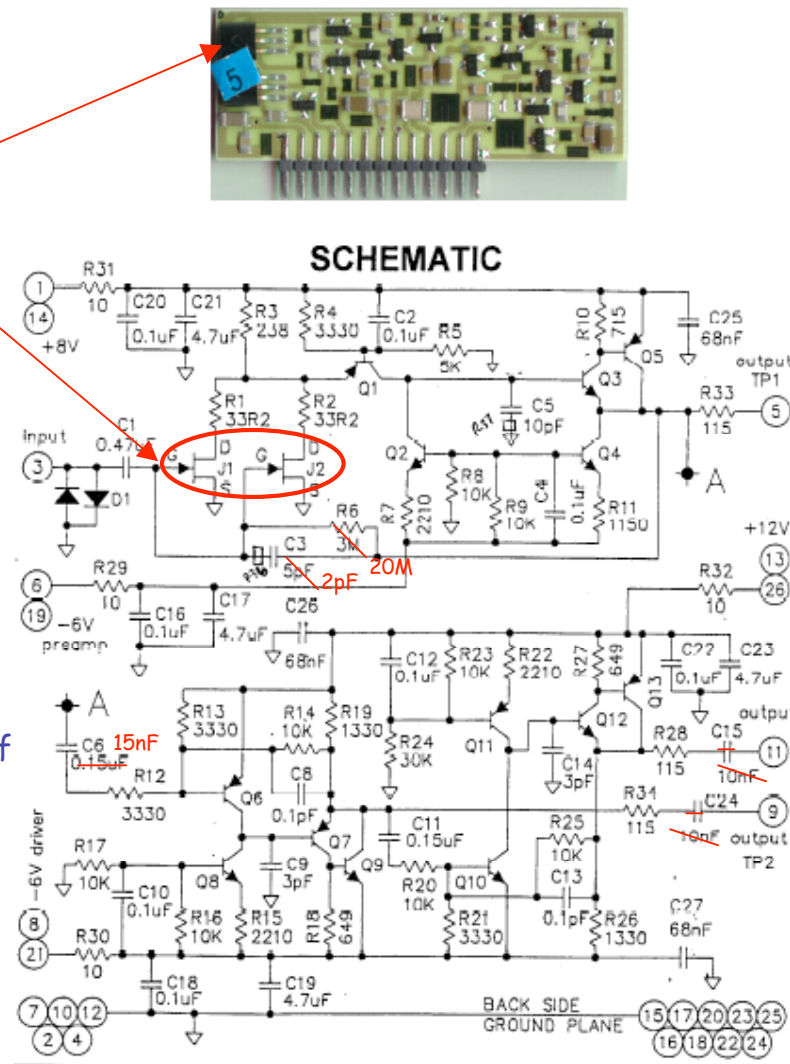
Modifications

Increase gain to 0.5 mV/fC

Increase RC to $40\ \mu\text{s}$

Note: Signals are $\sim 3 \mu\text{s}$

Will improve
low freq. cut-off

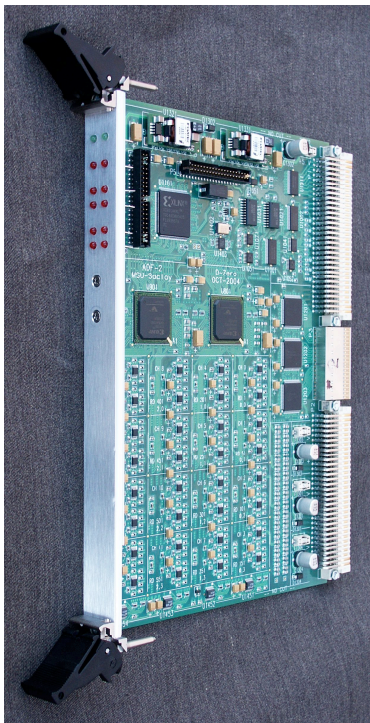


Output

Blocking now on preamp motherboard (PAB)

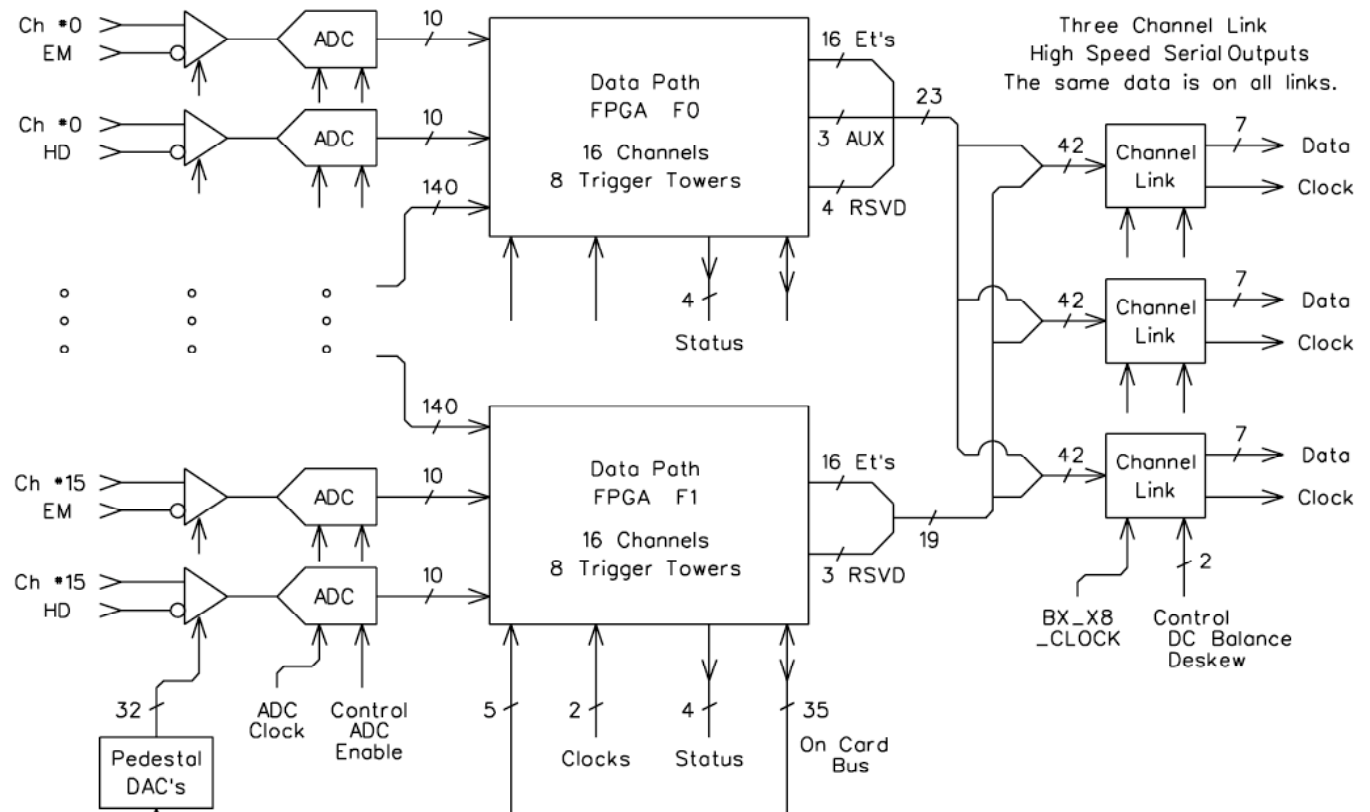
Analog to digital conversion

D-zero Run-II ADF-2 card



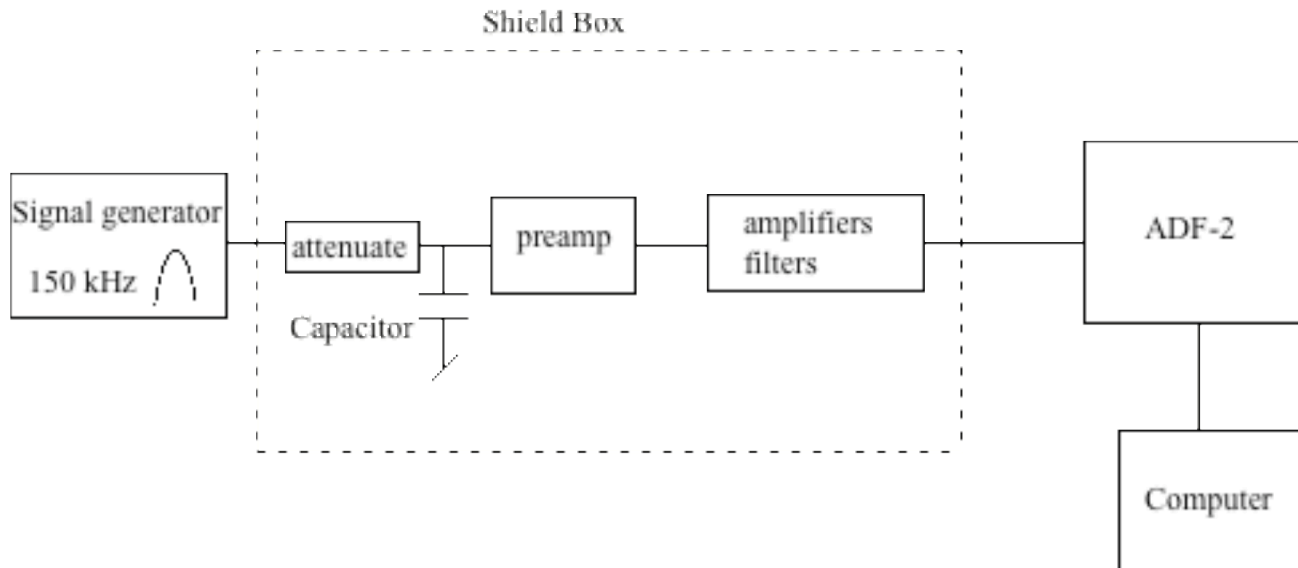
FPGA data storage field programmable

Example: 2048 samples
@ 5 MHz (400 μ s total)



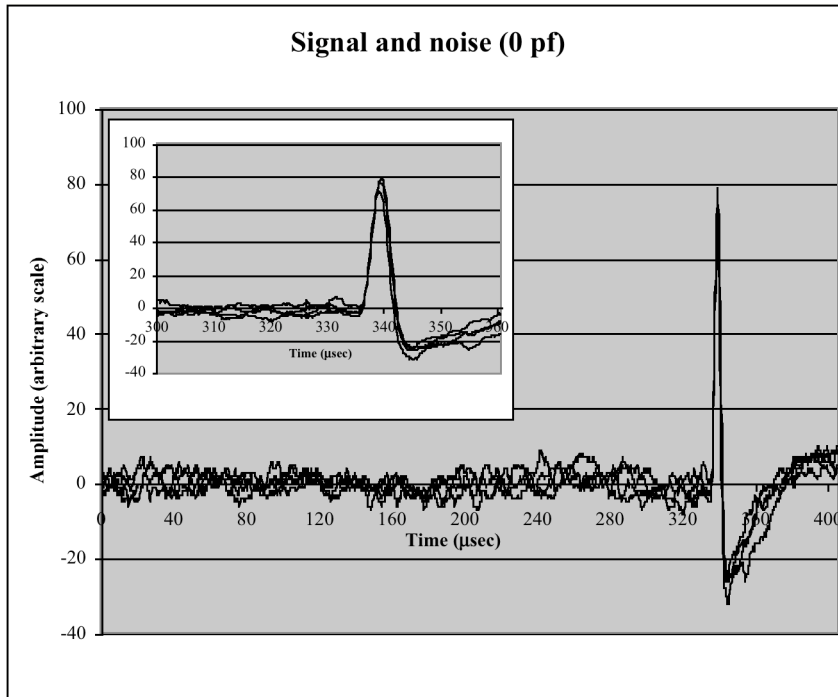
Designed and built at MSU by Dan Edmunds

Single Channel Test

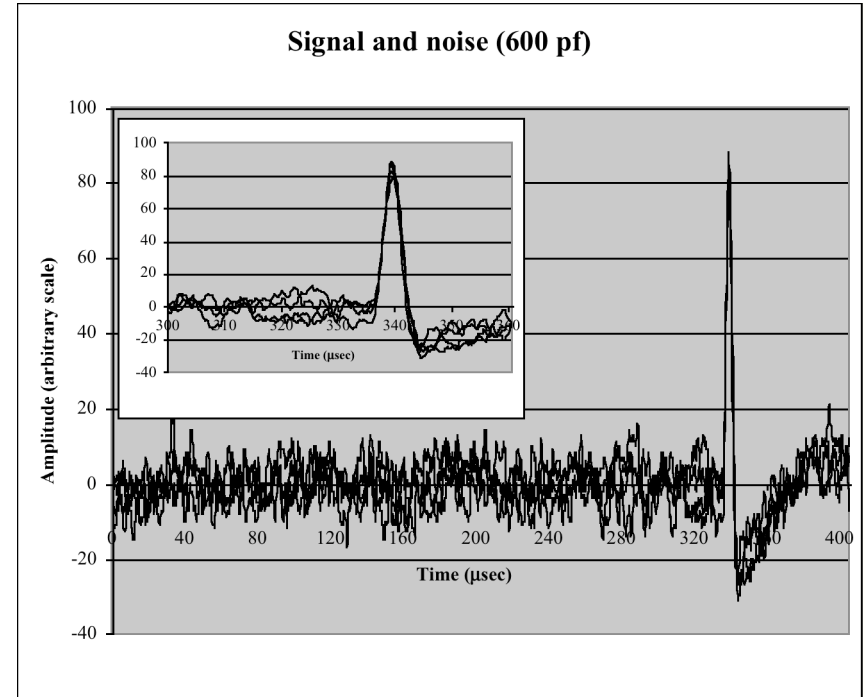


22,000 electron simulated signal

Capacitance 0-pf



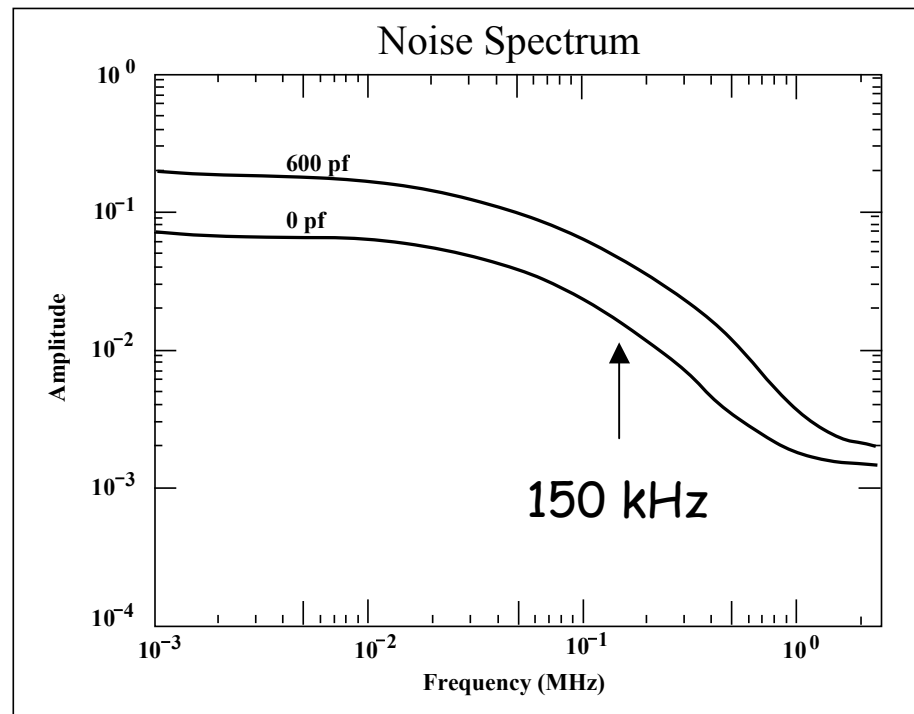
Capacitance 600-pf



Signal to noise can be estimated from these plots

Noise spectrum

Noise relative to 22,000 electron signal



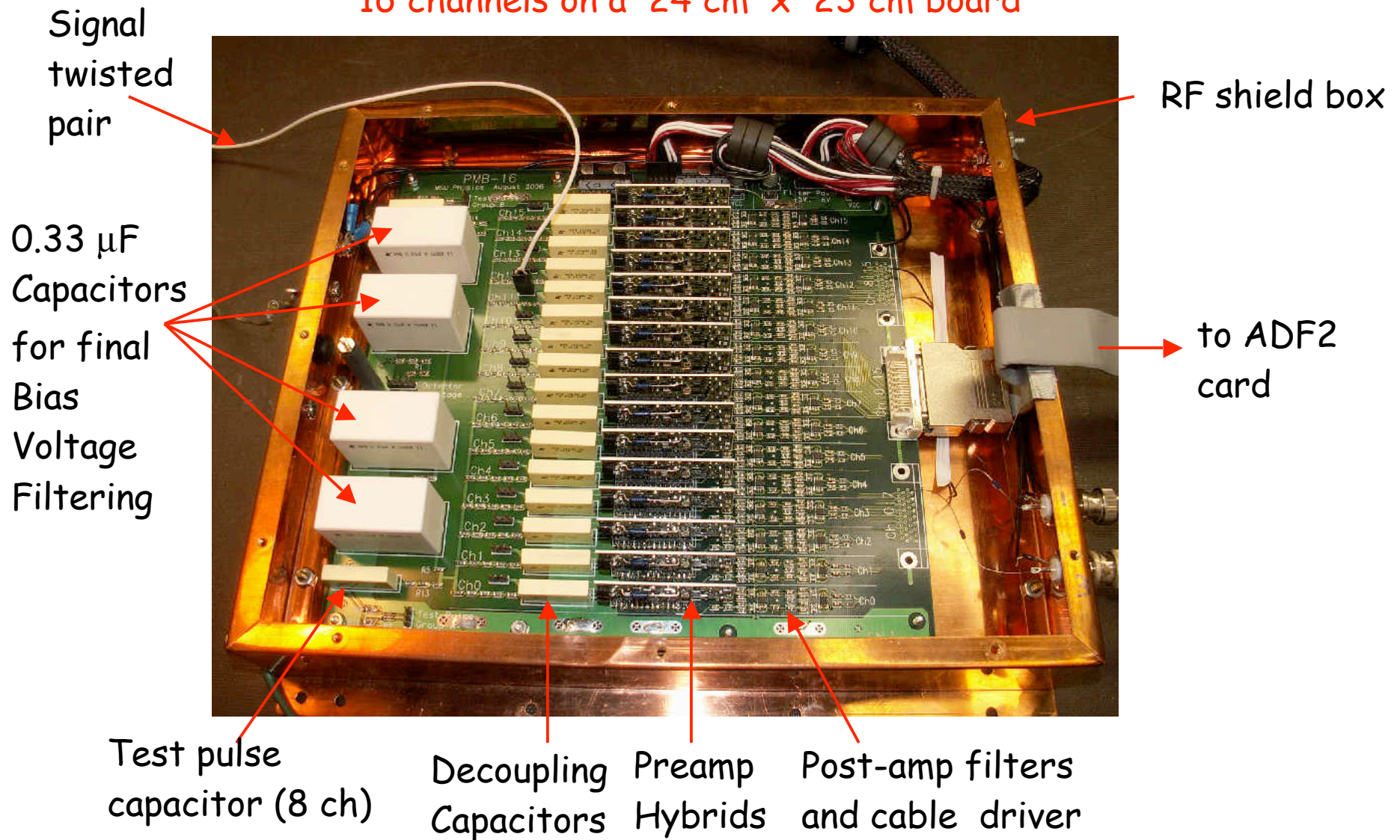
High pass & low
pass filters are
not optimized

Conclude that noise in these preamps is low enough for now.

OK to build a small system (~100 channels) based on these components

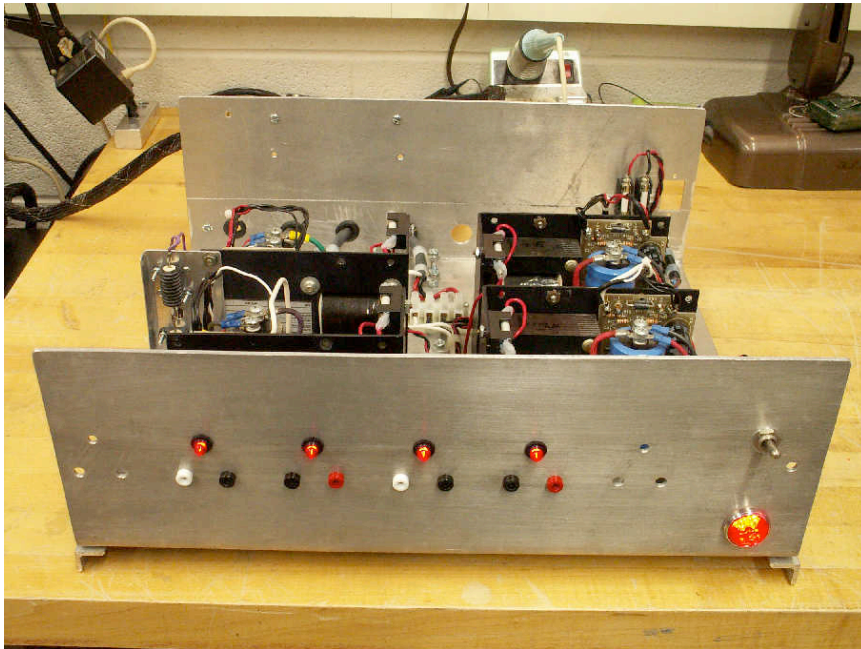
Preamp Motherboard (PMB)

16 channels on a 24 cm x 23 cm board

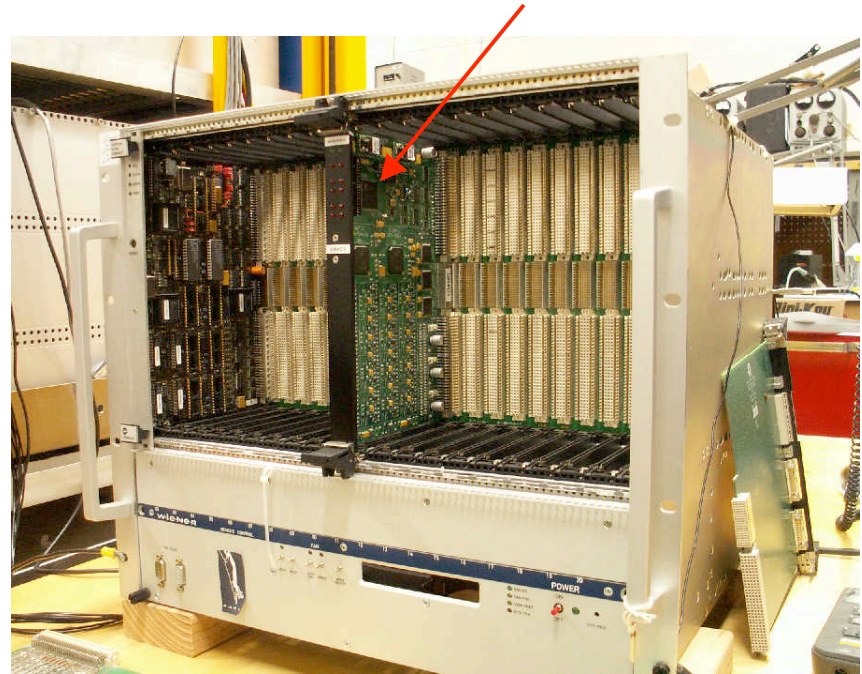


Other hardware

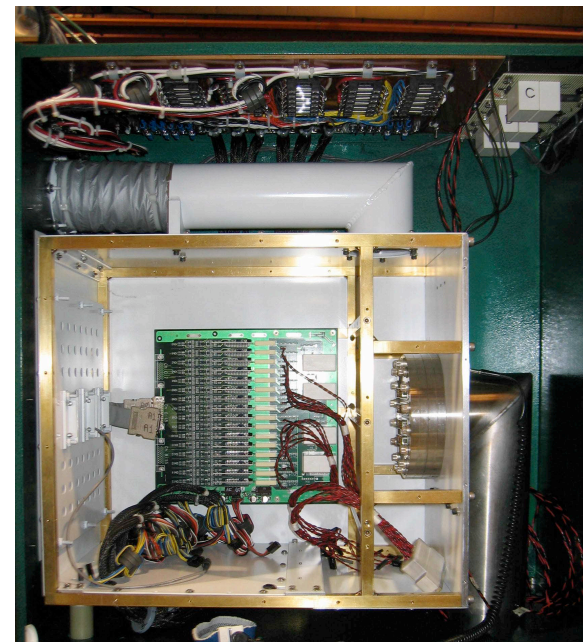
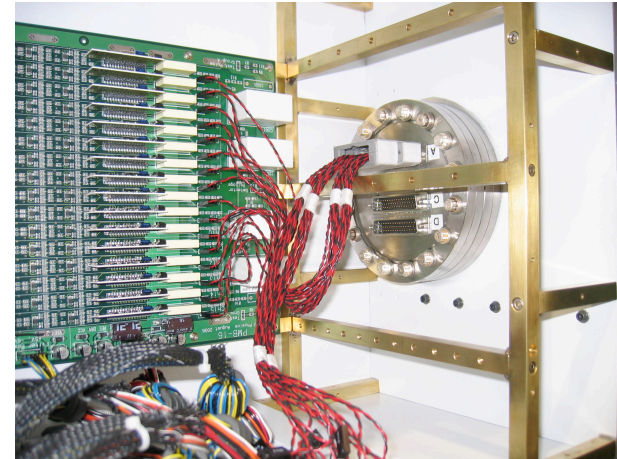
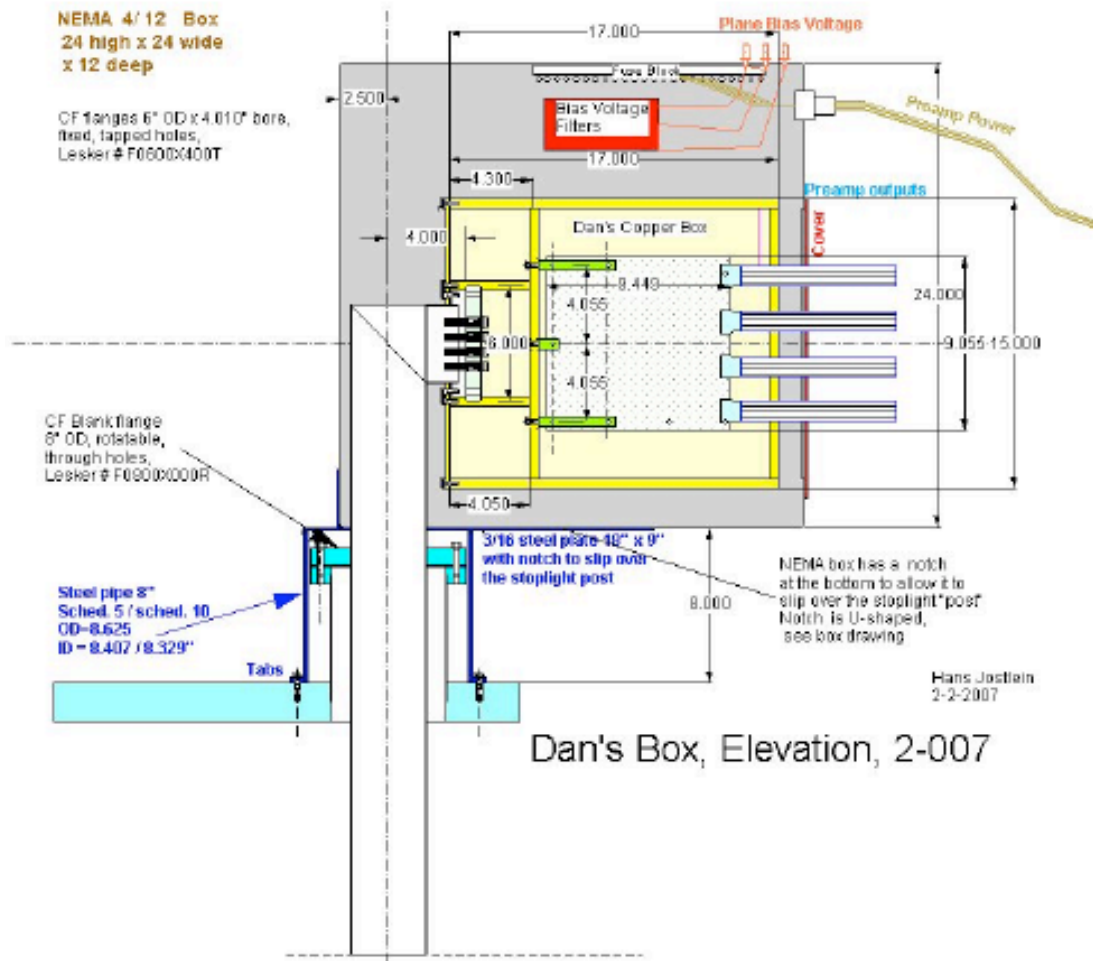
Preamplifier Power Supply



VME Crate with ADF2 card



Installed in PAB



Documentation

See - <http://www.pa.msu.edu/~edmunds/LArTPC/>
<http://lartpc-docdb.fnal.gov/doc/235>

- Hardware is well documented
 - Survey of state-of-the-art front end electronics
 - Tests of D0 preamplifier hybrids
 - Preamplifier modifications to optimize for LArTPC
 - Preamp motherboards <--> ADF2 channel mappings
 - **Grounding and shielding principles employed**
 - Much more
- DAQ software is in use at PAB
 - Run Control
 - Raw data displays
 - Simple data format (ascii files)
 - Event selector - data plotting

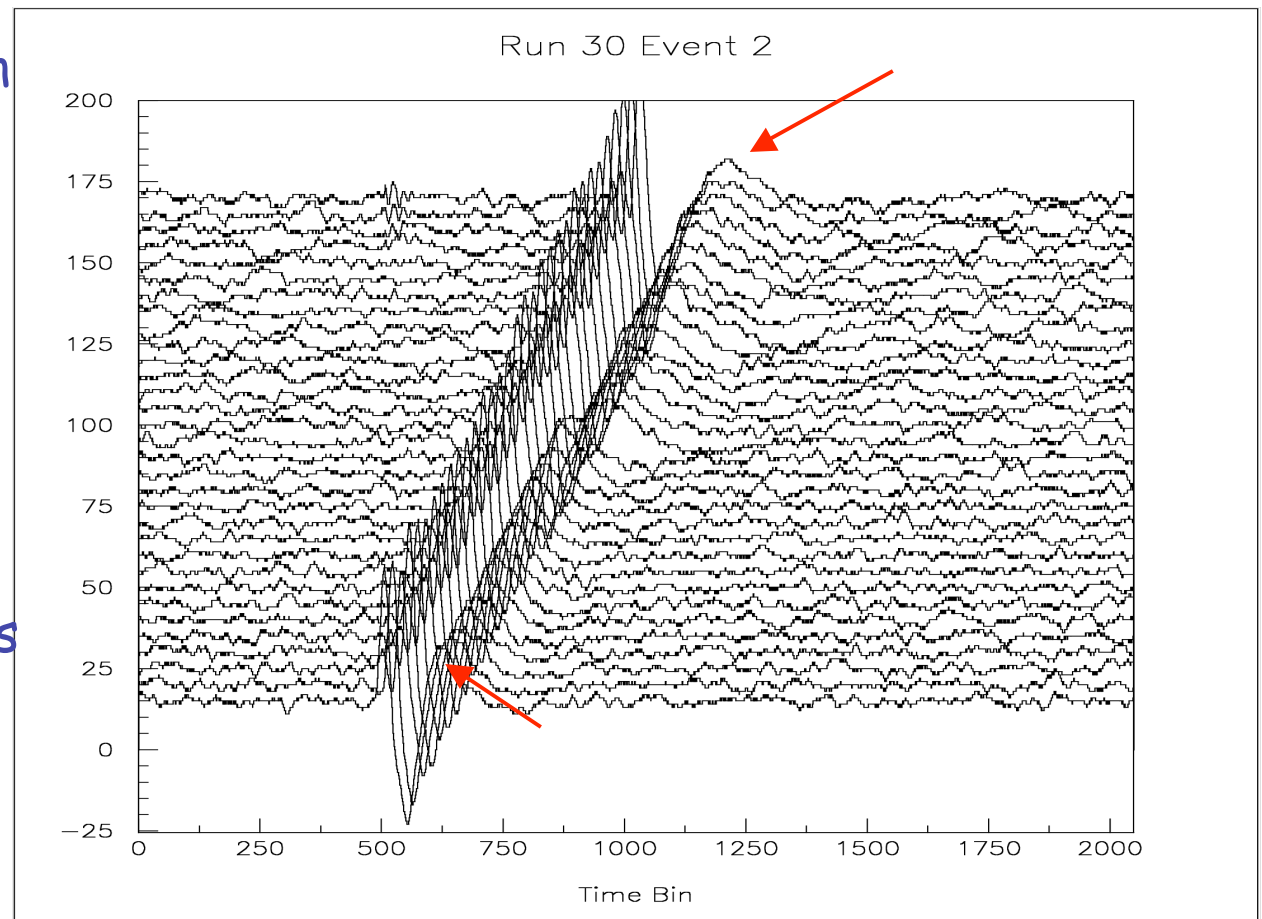
Battery powered "track" pulser

Online displays look like this

Each line is a single channel. 16 channels on each PMBoard.

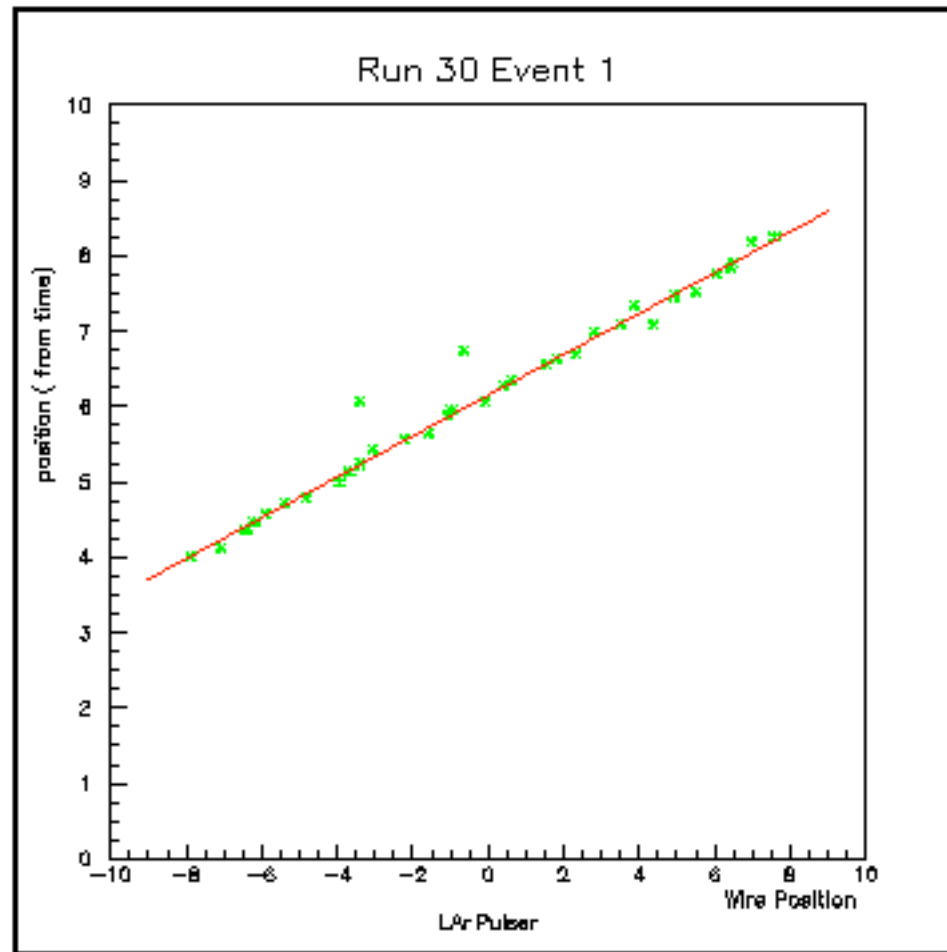
Two versions of PMB
Low freq. filter
difference is obvious

Noise RMS ~ 1-2 counts



Recreated from offline data by Doug Jensen

Doug's "track" finder



T-962

- Now that PAB system has been installed and tested, the specifics of T962 electronics can be addressed
- **Low noise systems need a CZAR.** Control over anything connected to a region defined as electronics or DAQ. If it generates noise (e.g., purity monitor, pulsers, level indicators, ...) -- it may need to be removed. Disconnecting from the exterior side of the feed-through may not be (or is likely not to be) sufficient.
- **Dan & Phillipe are NOT free.** D0 has paid for MSU electronics engineering services (design and operations) since the mid 80's. LArTPC R&D has only recently obtained a fraction of these services (FY07: Dan ~ 5 months, Phillipe a few weeks). T-962 design and installation will need at least this level of FY08 funding.

Approach to T-962 electronics

- The general principles of the design can be extracted nearly verbatim from existing PAB system documentation
- There are hybrids (caveats) and sufficient ADF2 modules for a < 500 channel system. Other borrowed items can be purchased. Design proceeding on this basis.
- However, PAB tests already suggest modifications to improve performance and/or solve problems
 - Feed - through design is made more difficult if bias voltage (~ 250 V) must be passed through to each wire
 - Mass terminated signal cables can be used, if bias voltage is not on the feed - through
 - Each hybrid needs ~ 5 modifications (tiny surface mount parts)
 - Commercial crates and higher density preamp cards can be used instead of existing homebrew mounting scheme
 - PAB TPC will be available to certify modifications. They will be in the direction needed for larger LArTPC
- Schedule (realistic?) may not allow sufficient time to do the needed R&D.

Cost and schedule

- Cost
 - \$10k in M&S was sufficient for the 96 channel PAB system, with many borrowed parts, and an engineer doing technician labor on personal time.
 - The 500 channel system for T-962 can save on scale, but the missing labor must be provided.
 - Realistically, a budgetary estimate of \$50k in M&S is appropriate.
 - A redesigned system could significantly reduce the cost but will likely impact the schedule.
- Schedule
 - If the basic system were fully funded, with a minimum of changes to the design, the components could be assembled in 6 months. Installation in another 1-2 months. (well into FY08).
 - A redesigned system, fully funded, could be installed in about 1 year.
- Improved estimates for cost and schedule can be provided in about 1 month.